Appendix I – Economics

DAM SAFETY ASSURANCE PROGRAM EVALUATION REPORT AND ENVIRONMENTAL IMPACT STATEMENT

APPENDIX I
ECONOMIC APPENDIX

DOVER DAM, OH
TUSCARAWAS RIVER

ECONOMIC ANALYSIS

1.0 Introduction

In accordance with ER 1110-2-1155, the Huntington District has completed a Dam Safety Assurance Final Evaluation report for the Dover Dam, located in the Muskingum River Basin in Ohio. Recent periodic inspections of the dam have revealed significant dam safety concerns. As a result of these inspections the Corps has determined that the dam is presently unable to withstand flooding resulting from theoretical Probable Maximum Flood (PMF) events. A breach of the Dover Dam would cause significant damage to properties downstream of the dam along the Tuscarawas River and several of its tributaries including the Licking, Stillwater, Little Stillwater, Muskingum, Walhonding Rivers and Wills Creek. This evaluation describes the expected losses to property, loss of project benefits, potential loss of life to the population at risk and other losses that would occur in the event of a failure of the Dover Dam.

1.1 Dover Dam Overview

Dover Dam is a concrete gravity dam constructed in 1937 as part of the Muskingum River System – a series of 14 reservoirs built in the Muskingum River Basin in response to local flood control needs. It is located in Tuscarawas County on the Tuscarawas River approximately 3.5 miles northeast of Dover, Ohio in central Ohio on State Highway No. 8. The dam's reservoir lies mostly in Tuscarawas County and the dam site itself is 174 miles above the confluence of the Tuscarawas with the Walhonding, forming the Muskingum River. The drainage area above the dam is 1,405 square miles. The project was placed into full operation in 1938. The elevation at the top of the dam is 931.5 feet, maximum length is 824 feet, and the crest elevation of the dam is 916 feet Mean Sea Level (MSL). The flood control capacity of the reservoir is 203,700 acre-feet. The area receiving most of the benefit consists of about 69,347 acres in the Muskingum River Basin between the dam site and the confluence of the Muskingum River with the Ohio River. Along with urban flood reduction, the Dover Dam reduces flooding for about 40,000 acres of agricultural land and related developments. As Dover Dam is a dry dam there is no designated pool depth.

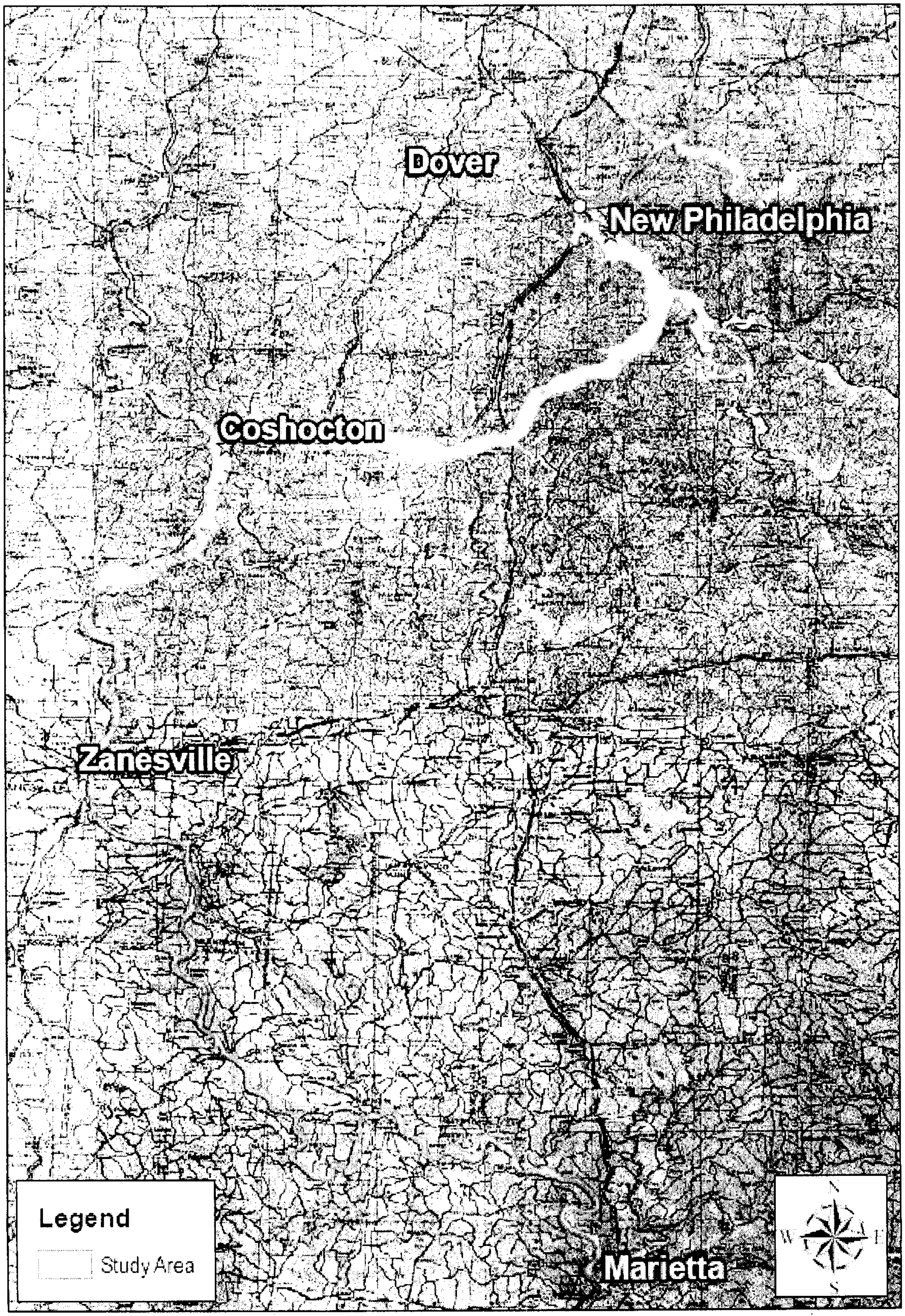
1.2 Study Area

This analysis covers the area that would be most significantly affected by the failure of Dover Dam, based on the results of the hydrologic dam-breach analysis for a Probable Maximum Flood (PMF) event. A PMF event is defined as the flood that may be expected from the most severe combination of critical meteorological and hydrologic conditions that are reasonably possible in the region. The PMF is a result of the Probable Maximum Storm, which can be described as the storm with the greatest depth of precipitation over a given duration that is theoretically possible for a given area.

To determine the study area for this report, hydraulic data of the dam failure analysis resulting from a PMF condition was used to delineate the floodplain of such an event on available mapping. This resulted in a study area spanning from the dam site downstream for approximately 75 linear miles, and approximately 125 stream miles. It includes a mix of residential, commercial and public facilities in the towns of Dover, New Philadelphia, Tuscarawas, Gnadenhutten and Uhrichsville, Ohio along with smaller communities in portions of Harrison County along the Tuscarawas River and some of its tributaries. Outside of these communities the study area is rural with very scattered development. There are approximately 300 miles of major highways in the study area that would be affected by a PMF dam failure. Those that are likely to be subjected to high velocities include portions of State Route 800 and Interstate 77. Other major highways that are expected to be impaired by floodwaters of a dam breach include portions of State Highway 36. Additionally there are 140 bridges affected by the flooding associated with a 100% PMF event. The majority of impacts would be realized in Tuscarawas County. New Philadelphia is the county seat of Tuscarawas County. In 2000, the population of Tuscarawas County was 91,944. A map of the general study area is provided as Figure 1.

Figure 1

Study Area



2.0 Project Benefits

The authorized project purposes of Dover Dam are flood damage reduction and recreation, from which project benefits are derived. Annual project flood control benefits for flood damage reduction are calculated by averaging the historic annual benefits. Recreation benefits for Dover Dam were calculated using the Unit Day Value (UDV) estimation method. Both of these categories are discussed in depth below.

2.1 Flood Reduction

The Dover Dam has prevented significant flooding over the life of the project. There have been no occurrences of water entering the spillway following completion of the project in 1938. As previously mentioned Dover Dam is one of 14 original flood control damns within the Muskingum Basin System. Benefits within the Muskingum River System are attributed to the entire system, rather than to individual projects. Previous studies have been performed to determine an appropriate breakdown of the total Muskingum Basin System benefits on a project by project basis that would be applicable to long term averaging. These studies involved a detailed analysis of several selected Muskingum River floods in which contribution by individual projects at each evaluation center was computed. Dover is credited with 15.2% of the total benefits attributed to the Muskingum River System as reported in *Piedmont Lake, Dam Safety Assurance Evaluation Report*, dated April 1996. The percentage breakdown per project in the Muskingum River System is presented in Table 1. This percentage was applied to historical damages prevented to derive a benefit distribution attributable to Dover.

Table 1 – Percentage Breakdown of Muskingum River System Benefits

Project	Percent of Total Benefits
Atwood	1.9
Beach City	10.3
Bolivar	6.7
Charles Mill	3.7
Clendening	1.7
Dover	**15.2**
Leesville	1.3
Mohawk	25.0
Mohicanville	6.4
Piedmont	1.3
Pleasant Hill	4.9
Senecaville	2.7
Tappan	2.1
Wills Creek	17.0

The historic damages prevented by both the Muskingum River System and Dover Dam are shown in Table 2. Historic damages prevented are shown both at the price level of each indicated year and in FY 2006 price levels. The yearly damages prevented are averaged to arrive at a number that represents the average of the annual benefits provided by the project. This number is $14,955,567 in FY 2006 levels. The total flood damages prevented by the project in FY 2006 price levels[1] for years 1937-2006 are approximately $1,046,889,674. These are based on aggregated stage-damage and benefit data developed by the original study for the system. The data has been adjusted in order to make appropriate estimates where current stream gage stations are located and are indexed to current price levels each year. Observed peak stages during each flood event that are above zero damage at the gages are compared with estimates of what the natural stages would have been without the constructed project in order to estimate flood damage reduction benefits for the year.

[1] With the exception of the historical damages prevented, all other dollar figures presented in Appendix I are in 01-Oct-2006 (FY07) dollars.

Table 2 – Historic Damages Prevented[2]

	Muskingum River System		Dover Dam	
Year	Historical Damages Prevented	Damages Prevented FY 2006 Price Level	Historical Damages Prevented	Damages Prevented FY 2006 Price Level
1937[3]	$1,834,286	$59,032,778	$279,545	$8,996,595
1938	$1,834,286	$58,782,639	$279,545	$8,958,474
1939	$1,834,286	$58,782,639	$279,545	$8,958,474
1940	$1,834,286	$57,325,218	$279,545	$8,736,363
1941	$1,834,286	$53,770,166	$279,545	$8,194,573
1942	$1,834,286	$50,263,416	$279,545	$7,660,145
1943	$1,834,286	$47,836,906	$279,545	$7,290,345
1944	$1,834,286	$46,397,000	$279,545	$7,070,903
1945	$1,834,286	$45,041,243	$279,545	$6,864,285
1946	$1,834,286	$40,094,517	$279,545	$6,110,404
1947	$1,834,286	$33,590,080	$279,545	$5,119,128
1948	$1,834,286	$30,092,631	$279,545	$4,586,117
1949	$1,834,286	$29,083,234	$279,545	$4,432,285
1950	$1,834,286	$27,201,378	$279,545	$4,145,490
1951	$1,834,286	$25,548,256	$279,545	$3,893,554
1952	$1,834,286	$24,380,849	$279,545	$3,715,641
1953	$1,834,286	$23,121,171	$279,545	$3,523,667
1954	$1,834,286	$22,090,291	$279,545	$3,366,560
1955	$1,834,286	$21,019,247	$279,545	$3,203,333
1956	$1,834,286	$20,047,258	$279,545	$3,055,202
1957	$1,834,286	$19,161,192	$279,545	$2,920,166
1958	$4,008,000	$39,937,423	$610,819	$6,086,463
1959	$14,446,000	$137,082,934	$2,201,570	$20,891,439
1960	$1,574,000	$14,446,799	$239,878	$2,201,692
1961	$7,531,000	$67,245,517	$1,147,724	$10,248,217
1962	$2,204,000	$19,115,656	$335,890	$2,913,226

[2] Data for years 1937-1957 is estimated because complete yearly historical records were not available; however the cumulative total through 1957 of $38,520,006 was on record. The cumulative total was divided by the 21 years that the system had been in operation to yield a yearly estimate.

[3] Though the dam was placed into operation in 1938 as stated in Section 1.0 there were partial damages prevented in the year before as construction of the dam was underway.

Table 2 – Historic Damages Prevented Cont'[4]

	Muskingum River System		Dover Dam	
Year	Historical Damages Prevented	Damages Prevented FY 2006 Price Level	Historical Damages Prevented	Damages Prevented FY 2006 Price Level
1963	$19,070,000	$160,073,707	$2,906,268	$24,395,233
1964	$8,779,500	$70,939,486	$1,337,996	$10,811,178
1965	$8,779,500	$68,382,450	$1,337,996	$10,421,485
1966	$8,779,500	$65,161,294	$1,337,996	$9,930,581
1967	$8,779,500	$61,824,356	$1,337,996	$9,422,032
1968	$2,817,000	$18,445,862	$429,311	$2,811,149
1969	$3,273,000	$19,506,461	$498,805	$2,972,785
1970	$53,384,000	$292,355,678	$8,135,722	$44,555,005
1971	$10,941,000	$52,338,256	$1,667,408	$7,976,350
1972	$5,196,000	$22,417,198	$791,870	$3,416,381
1973	$2,780,000	$11,095,061	$423,672	$1,690,887
1974	$8,290,000	$31,038,252	$1,263,396	$4,730,230
1975	$77,522,000	$265,053,746	$11,814,353	$40,394,191
1976	$55,252,000	$174,040,348	$8,420,405	$26,523,749
1977	$48,683,000	$142,930,718	$7,419,289	$21,782,641
1978	$97,136,000	$264,639,614	$14,803,526	$40,331,077
1979	$255,384,000	$643,179,884	$38,920,522	$98,020,614
1980	$85,960,000	$200,838,888	$13,100,304	$30,607,847
1981	$58,514,000	$125,188,510	$8,917,534	$19,078,729
1982	$28,083,000	$55,527,249	$4,279,849	$8,462,353
1983	$58,564,000	$108,932,497	$8,925,154	$16,601,313
1984	$22,527,000	$41,093,030	$3,433,115	$6,262,578
1985	$57,276,000	$103,260,641	$8,728,862	$15,736,922
1986	$39,321,000	$69,239,749	$5,992,520	$10,552,138
1987	$44,358,000	$76,141,524	$6,760,159	$11,603,968
1988	$15,600,000	$26,108,166	$2,377,440	$3,978,884
1989	$43,836,000	$71,837,848	$6,680,606	$10,948,088
1990	$66,950,000	$107,003,984	$10,203,180	$16,307,407
1991	$112,601,000	$176,132,650	$17,160,392	$26,842,616
1992	$1,930,000	$2,928,102	$294,132	$446,243

[4] Data for the individual years of 1964-1967 was also not available so the cumulative total for those years was divided by 4 to yield a yearly estimate.

Table 2 – Historic Damages Prevented Cont'

	Muskingum River System		Dover Dam	
Year	**Historical Damages Prevented**	**Damages Prevented FY 2006 Price Level**	**Historical Damages Prevented**	**Damages Prevented FY 2006 Price Level**
1993	$60,410,000	$87,693,058	$9,206,484	$13,364,422
1994	$164,371,000	$229,870,169	$25,050,140	$35,032,214
1995	$17,145,000	$23,700,902	$2,612,898	$3,612,017
1996	$240,370,000	$323,473,009	$36,632,388	$49,297,287
1997	$54,061,000	$70,179,084	$8,238,896	$10,695,292
1998	$153,775,000	$196,452,758	$23,435,310	$29,939,400
1999	$68,298,000	$85,251,324	$10,408,615	$12,992,302
2000	$25,943,000	$31,539,448	$3,953,713	$4,806,612
2001	$26,325,000	$31,388,298	$4,011,930	$4,783,577
2002	$17,614,000	$20,375,448	$2,684,374	$3,105,218
2003	$29,815,000	$33,685,516	$4,543,806	$5,133,673
2004	$478,489,000	$508,617,331	$72,921,724	$77,513,281
2005	$609,288,000	$618,861,824	$92,855,491	$94,314,542
2006	$10,121,000	$10,121,000	$1,542,440	$1,542,440
Total Benefits	**$3,334,674,000**	**$6,869,354,815**	**$508,204,318**	**$1,046,889,674**
Average Annual Benefits	**$47,638,200**	**$98,133,640**	**$7,260,062**	**$14,955,567**

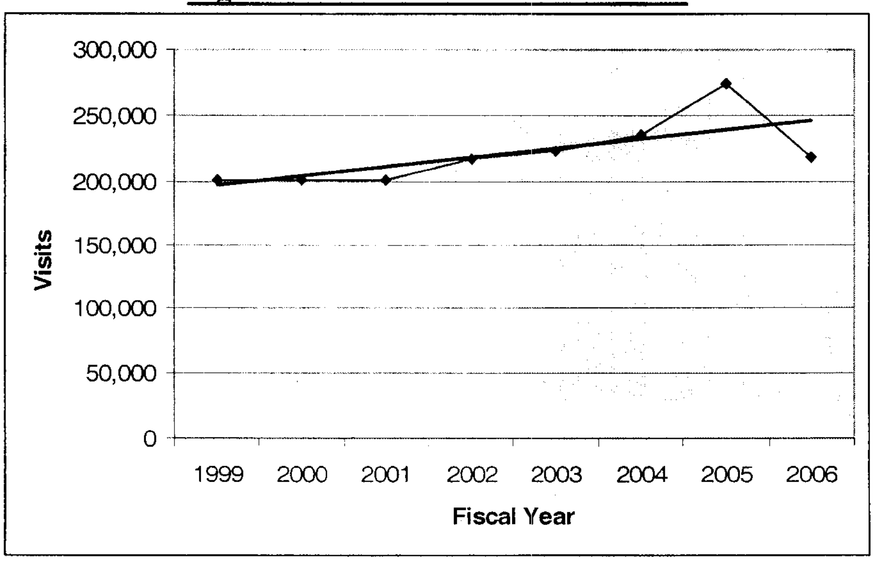
2.2 Recreation

Recreation at the Dover Dam site is limited and consists of day use facilities set up primarily for picnicking and fishing, via an access road and adjacent parking lot. However, as the dam is considered a significant cultural and aesthetic resource to the region, a large portion of visitation at the project facilities is in the form of sightseers viewing the dam from its viewing areas. Annual data for the project was obtained from the Operations and Maintenance Business Information Link (OMBIL) system for the past 8 years, from 1999 to date. Average annual visitation at Dover Dam totals 221,293 visits and is presented in Table 3. The historic annual visitation and the resulting trend line are presented graphically in Figure 2.

Table 3 - Recent Historic Visitation

Year	Annual Visits
2006	218,432
2005	273,714
2004	234,948
2003	222,842
2002	216,963
2001	201,100
2000[5]	201,149
1999	201,198
Average	221,293

Figure 2 – Recent Historic Visitation



[5] This number was 402,502 when the information was originally taken from OMBL. In an effort to use data that was more reflective of current visitation trends at Dover Dam, it was not used. This number was replaced by the average number of annual visits from 2001 to 1999 which was 201,149.

In compliance with Economic Guidance Memorandum, 07-03, the Unit Day Value (UDV) estimation method was employed as a proxy for willingness to pay in order to estimate the current recreation benefit of Dover Dam. The Unit Day Method employs a set of five criteria (recreation experience, availability of opportunity, carrying capacity, accessibility and environment) upon which the project site is evaluated and assigned points. The point total is then multiplied by a recreation value to determine the recreation benefit. Estimated point assignments for each recreation component were agreed upon by the project design team's economist and environmental planner and are presented in Table 4.

Table 4 - Point Assignments to Determine Recreation Benefit

Criteria	Points	Comments
Recreation Experience	2	There are two general activities.
Availability of Opportunity	3	Several within 1 hour travel time; a few within 30 minutes travel time.
Carrying Capacity	0	Minimum facility for development for public health and safety.
Accessibility	7	Fair access, fair road to site; fair roads within site.
Environmental	7	Above average esthetic quality; any limiting factors can be reasonably rectified.
Total	19	

The average of the annual visitation to Dover Dam for the preceding eight years is 221,293, as previously stated. With 19 estimated general recreation points, the appropriate unit day value is $4.32, yielding estimated total annual recreation benefits of $955,986 ($4.32 x 221,293 annual visits = $955,986).

2.3 Total Project Benefits

Total quantified annual Dover Dam benefits are $15,911,986 as shown in Table 5.

Table 5 - Summary of Annual Benefits

Benefit	Annual Benefits (FY 2007 Price Level)
Flood Control	$14,956,000
Recreation	$955,986
Total	**$15,911,986**

The total project benefits were also used to calculate the annual project benefits, the benefit to cost ratio and project net benefits at the conclusion of this appendix.

3.0 Economic Losses Associated with Probable Maximum Flood

Due to the certainty of loss of life from failure to conform to current design standards related to stability and sliding during a PMF event, Dover Dam is currently classified as a high hazard dam. It should be noted that flooding associated with a Probable Maximum Flood (PMF) would cause significant damage beyond the study limits of this evaluation. The economic losses that would occur both with and without dam failure include damage resulting from inundation to residential, commercial, industrial and public properties and their contents in addition to farms and cropland.

In order to fully determine the extent of economic damage resulting from a PMF event it is necessary to simulate such an event in the Hydrologic Engineering Center's Flood Damage Analysis (HEC-FDA) program. The HEC-FDA program is used to assist PDT members in using risk analysis methods for flood damage reduction studies as required by Corps guidance in EM 1110-2-1319. (For the purpose of this study it was utilized to assign a dollar amount to the economic losses resulting from a PMF affecting Dover Dam.) The program incorporates descriptions of uncertainty of key parameters and functions into project benefits and performance analysis. There are several inputs to the program, including the following: a structure inventory containing structure value and first floor elevation, hydrologic data, and depth damage curves.

Because there have been no recent updates of the floodplain damage data of the original project study published in the "1934 Agreement," it was necessary to perform an inventory of damageable properties in the study area to produce a structure inventory. In order to obtain a count of structures in the study area, inundation mapping resulting from the HEC-RAS modeling of a PMF flood event was overlaid on USGS 7.5-minute quad sheets with ten-foot contour intervals. This provided a first estimate of the number of structures in the study area. In order to identify changes in development from that shown on the original topographic maps, aerial photography was obtained from Terra Server using an ArcView extension and overlaid on the quads. The total number of structures were counted which resulted in a structure count that is consistent with current development in the area. First floor elevations and values of commercial structures were estimated from Hazus surface mapping in conjunction with USGS digital elevation models. Structure values for residential structures were taken from the "Median value of owner-occupied housing units" on the U.S. Census Bureau's website. Since Hazus only shows the ground elevation of a structure, two feet was added to the ground elevation each structure's elevation to arrive at an estimated first floor elevation. Hydrologic data was provided from modeling as performed by Hydraulics and Hydrology.

As stated, depth-damage curves for residential and commercial structures were imported into the HEC-FDA program. The residential depth-damage relationships used were published in Economics Guidance Memorandum 01-03, Generic Depth-Damage Relationships (for residential structures without basements) dated 4 December 2000. The categories within the residential depth-damage functions include: one-story – no basement; one-story – with basement; two-story – no basement; two-story – with basement; and split-level with no basement. For the purposes of this study all residential structures, including mobile homes were categorized as one-story – no basement. Those curves utilized for commercial structures were the "New Orleans" commercial depth damage functions. The categories within the commercial depth-damage functions include the following: eating & recreation; grocery & gas station; multi-family units (over 5); professional services; public facilities; repairs & home use; retail & personal services; and warehouses & contractors.

3.1 Economic Losses Without Failure

The results of FDA modeling for the Tuscarawas River indicate that 6,923 structures in the study area would be inundated during a PMF event without dam failure. Residential structures expected to be flooded total 6,045 and commercial number 878. Public structures were included with commercial structures during the damage survey. Estimated urban flood damage associated with a PMF event without dam failure would total approximately $704,635,000. Residential damage would account for 83% of total damage, and commercial damage would account for 16% of total damage. This information is presented in Tables 6 and 7.

Table 6 - Numbers of Structures and Depths of Flooding Without Dam Failure

County	Damage Category	Number of Structures	Depths of Flooding (in ft)	
			Maximum	Average
Total	Residential	6,045	144.19	59.14
	Commercial	878	89.48	50.02
	Total	6,923	144.19	58.43
Coshocton	Residential	2,494	124.8	53.21
	Commercial	432	37.75	26.28
	Total	2,926	-	-
Morgan	Residential	433	138.52	108
	Commercial	0	-	-
	Total	433		
Muskingum	Residential	1,187	133.33	77.83
	Commercial	0	-	-
	Total	1,187		
Tuscarawas	Residential	1,931	88.15	47.08
	Commercial	446	81.39	57.24
	Total	2,377	-	-

Table 7 - Study Area Flood Damage, PMF-Level Dam Failure Without Dam Failure

County	Damage Category	Damage, FY 2007 Price Level (x1000)
Total	Residential	$589,685
	Commercial	$114,950
	Total	$704,635
Coshocton	Residential	$231,917
	Commercial	$124,086
	Total	$356,003
Morgan	Residential	$34,870
	Commercial	$0
	Total	$34,926
Muskingum	Residential	$118,739
	Commercial	$0
	Total	$119,456
Tuscarawas	Residential	$204,158
	Commercial	$245,595
	Total	$449,753

3.2 Economic Losses With Dam Failure

The results of FDA modeling for a breached Dover dam indicate that 12,703 structures in the study area would be inundated during a PMF event without dam failure. Residential structures expected to be flooded total 11,442 and commercial number 1,261. Estimated urban flood damage associated with a PMF event without dam failure would total approximately $1,646,296,000. Residential damage would account for 70% of total damage, and commercial damage would account for 30% of total damage. This information is compiled in Tables 8 and 9.

Immediate impacts due to a dam failure include loss of access to emergency services and several stretches of roads and highways, as well as damage to properties in the study area. Agriculture losses beyond those included in average annual benefits were not included in this evaluation. However it should be noted that a PMF dam failure would flood approximately 40,720 total crop acres in the study area with corn and soybeans as the primary crops grown. Annual recreation benefits of Dover Dam are described above. Annual benefits of the project would be lost while it was repaired or rebuilt.

Table 8 - Numbers of Structures and Depths of Flooding With Dam Failure

County	Damage Category	Number of Structures	Depths of Flooding (in ft)	
			Maximum	Average
Total	Residential	11,442	144.19	59.14
	Commercial	1,261	89.48	50.02
	Total	12,703	144.19	58.43
Coshocton	Residential	2,674	134.71	57.9
	Commercial	415	43.42	29.3
	Total	3,089	-	-
Morgan	Residential	432	144.19	113.67
	Commercial	0	-	-
	Total	432		
Muskingum	Residential	1,194	139	83.1
	Commercial	0	-	-
	Total	1,194		
Tuscarawas	Residential	7,142	103.96	52.29
	Commercial	846	89.48	60.19
	Total	7,988	-	-

Table 9 - Study Area Flood Damage, PMF-Level Dam Failure Without Dam Failure

County	Damage Category	Damage, FY 2007 Price Level (x1000)
Total	Residential	$1,153,110
	Commercial	$493,186
	Total	$1,646,296
Coshocton	Residential	$243,454
	Commercial	$124,086
	Total	$367,540
Morgan	Residential	$34,926
	Commercial	$0
	Total	$34,926
Muskingum	Residential	$119,456
	Commercial	$0
	Total	$119,456
Tuscarawas	Residential	$755,274
	Commercial	$369,100
	Total	$1,124,374

3.3 Cultural Resources

In addition to structural damage there are several structures and places within the study area that are listed on the National Register of Historic Places. These structures include but are not limited to the Frederick Bernhard House, the Katherine Cooper House, and the Johnson Site II (all located in Dover). Another property of importance that might be impacted by a PMF dam failure at Dover is a portion of the Ohio & Erie Canal Towpath Trail that runs adjacent to the project site. A full discussion of potential impacts to cultural resources can be found in the main report of this evaluation in section 1.6.11.

4.0 Population at Risk

A Bureau of Reclamation report entitled *A Procedure for Estimating Loss of Life Caused by Dam Failure*, by Wayne J. Graham, dated September 1999, contains a methodology for estimation of loss of life due to dam failure based on flood severity. A high severity flood would most likely be caused by failure of a dam occurring within seconds rather than minutes or hours.

In *A Procedure for Estimating Loss of Life Caused by Dam Failure*, Graham defines population at risk (PAR) as "the number of people occupying the dam failure floodplain prior to the issuance of any warning." The number of people in the floodplain will vary by day and by season. PAR includes both permanent and transient population. Permanent population is composed of residents in the affected areas. The transient population is made up of workers coming into the affected area to work. PAR estimates are utilized in making estimates of loss of life. Estimates of the PAR were made by deriving the average number of people per household for the counties in the study area from 2000 census data and multiplying these by the number of residences in each area with damage potential. Household sizes of each county in the study area range from 2.50 to 2.53. The study area was broken down by county and the average number of people per house household was assigned accordingly. Total population at risk is estimated to be 70,872, of which 25,162 are in the high severity flood zone and 45,710 in the medium severity flood zone.

For the intent of this study the transient population is considered to be workers at commercial structures in the study area. There are several industrial and large commercial facilities within the 1 hour arrival time of the flood wave. The average number of workers per facility was derived using NAICS data for the counties within the study area. The total number of commercial properties was divided by the number of workers to arrive at an average number of workers per structure. The commercial structures were broken out by county and each average assigned accordingly.

5.0 Loss of Life Potential with Dam Failure

Population at risk estimates are utilized in making estimates of loss of life resulting from a failure of the dam. It is extremely difficult to predict the potential for loss of life with dam failure. This potential depends on the severity of the flood event, the speed of dam failure, size of the population at risk, the amount of warning time, and the effectiveness of evacuation measures along with many other variables. As previously mentioned, a flood severity based methodology presented in *A Procedure for Estimating Loss of Life Caused by Dam Failure* was employed in the estimate of potential loss of life for this study. Guidelines provided in the report to differentiate between high, medium and low flood severity were followed in this evaluation. The failure of Dover Dam would result in high severity flooding from the dam downstream to New Philadelphia.

The medium severity flood zone downstream of the dam was determined by subtracting the mean annual discharge from the discharge caused by dam failure at specific stream stations and dividing the result by the maximum width of flood caused by the dam failure. The resulting value is in units of feet squared per second (ft^2/s) and serves as a proxy for depth and velocity and is representative of the general level of destructiveness caused by dam failure flooding. The report states that a value of 50 ft^2/s is generally the breakpoint between medium and low severity flooding.

Fatality rate values for flood zones applied to PAR provided the estimate of potential loss of life caused by a failure of the dam. Major factors that affect the loss of life estimate other than flood severity are warning time and the relative understanding of the flood severity. The recommended fatality rates from the Bureau of Reclamation report are presented in the following table.

Table 10 - Recommended Fatality Rates for Estimating Loss of Life from Dam Failure

Flood Severity	Warning Time (min)	Flood Severity Understanding	Fatality Rate (Fraction of People at Risk Expected to Die)	
			Suggested	Suggested Range
High	No Warning	N/A	0.75	.30 to 1.00
	15 to 60	Vague	Use the values shown above and apply to the number of people who remain in the dam failure floodplain after warnings are issued. No guidance is provided on how many people will remain in the floodplain.	
		Precise		
	More than 60	Vague		
		Precise		
Medium	No Warning	N/A	0.15	0.03 to 0.35
	15 to 60	Vague	0.04	0.01 to 0.08
		Precise	0.02	0.005 to 0.04
	More than 60	Vague	0.03	0.005 to 0.06
		Precise	0.01	0.002 to 0.02
Low	No Warning	N/A	0.01	0.0 to 0.02
	15 to 60	Vague	0.007	0.0 to 0.015
		Precise	0.002	0.0 to 0.004
	More than 60	Vague	0.0003	0.0 to 0.0006
		Precise	0.0002	0.0 to 0.0004

Warning time for a potential Dover Dam failure is expected to be greater than 60 minutes, therefore the resulting expected loss of life is 18,871. There are several mitigating factors that would result in a loss of life number much lower than this. First, if failure occurs during a PMF event, downstream flooding and the severity of flooding leading up to a PMF event would result in the majority of the population having already removed from the inundation area. Also, in the case of a PMF dam failure at Dover, extensive monitoring would take place, resulting in a higher warning time for those who still are in the floodplain. Therefore, the original expected loss of life was adjusted for these factors using the DeKay and McClellend equation referenced in Graham's "A Procedure for Estimating Loss of Life Caused by Dam Failure." The resulting estimate of the probable loss of life of a Dover Dam PMF failure ranges from 49 to1,000. The values leading to this estimate are presented in Table 11. It should be noted that loss of life estimates are extremely uncertain. There is no way to predict the actual impact to human life from a dam breach. The estimation of potential loss of life for this analysis is not intended to place a value on human life. This analysis is presented solely to illustrate the potentially catastrophic nature of a failure of the Dover Dam. For a more detailed discussion of Loss of Life with dam failure see Appendix C, Tab 1.

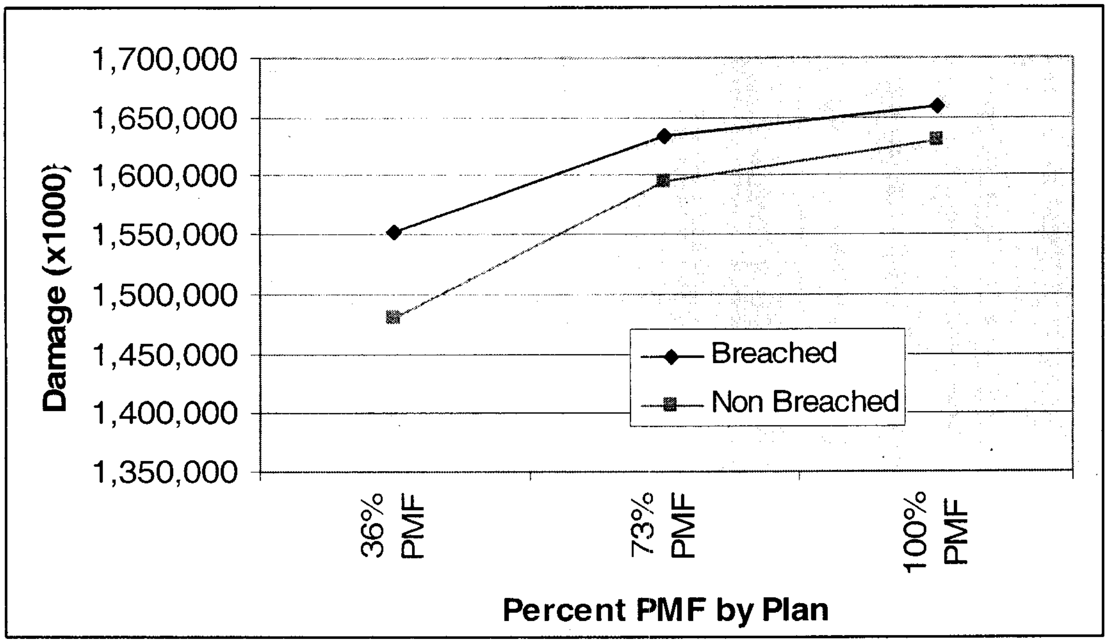
Table 11 - Population at Risk and Loss of Life with PMF-Level Dam Failure

Location	Flood Severity	Population at risk	Recommended Fatality Rate	Warning Time (hours)	Expected Loss of Life	Adjusted Loss of Life
Tuscarawas River (Dam to New Philadelphia)	High	25,162	0.75	1	18,871	49
Tuscarawas River to Muskingum River	Medium	12,956	0.03	6	389	0
Tributaries of the Tuscarawas River	Medium	7,872	0.03	12	236	0
Muskingum to Ohio River	Medium	20,260	0.03	32	608	0
Tributaries of the Muskingum river	Medium	4,622	0.03	32	139	0

6.0 Recommended Plan

Guidance provided in ER 1110-2-1155 *Dam Safety Assurance Program*, was followed in selecting the recommended plan to address the concerns caused by the current state of the project. Specific formulation guidance for DSA projects is located in EC 1110-2-6061, "Safety of Dams – Policy and Procedures". This guidance states that, "recommended plans under the dam safety assurance program, except in certain circumstances, meet or exceed the Base Safety Condition (BSC)." The BSC is defined as the flood where no significant economic damages or probable loss of life is incurred from dam failure as compared to that of non-failure. As depicted in figure 2, the BSC evaluation for the Dover project indicated that the economic damages were always greater during dam failure for floods up to 100% of the PMF. As previously described in Section 5, dam failure would also result in significant loss of life. Therefore, the 100% PMF was determined to be the BSC for this project. For the purposes of this study, the BSC was considered a minimum standard which all alternatives must achieve.

Figure 3



The recommended alternative would allow for the dam to safely pass the 100% PMF. Generally, this would entail raising the existing non-overflow sections with concrete parapet walls constructed on the existing dam. I-wall sections would also be added to continue the parapet walls to their termination at high ground. A gate closure would also be constructed across Ohio Route 800. In order to stabilize the dam against sliding the recommended alternative also includes the addition of 27 anchors across the spillway section of the dam, and 130 anchors to the stilling basin. A more detailed discussion of the recommended alternative is included in section 2.4.2.2 of the main report of this evaluation.

7.0 Summary

The total estimated first cost of repair to the Dover Dam, with contingencies, is estimated to be $100,779,365. Interest during construction was calculated for a 7 year construction period and these costs were annualized at 4.875% (the FY 2007 Federal discount rate) over the 50 year period of analysis. Annualized project costs are $5,682,398. Compared to total annual benefits of the project, described above, the recommended alternative has positive net benefits of $10,191,168 and a benefit to cost ratio of 2.8. The summary of annual benefits and costs for the recommended plan is presented in Table 10.

Table 12 - Summary of Annual Benefits and Cost, Recommended Plan

		FY 2007 Price Levels, 4.875% Interest Rate (x1000)
Project Cost	Construction First Cost	$92,064
	Interest during Construction	$13,671
	Total Investment Cost	$105,736
Annual Charges	Interest and Amortization	$5,680
	Operation and Maintenance[6]	$2
	Total Average Annual Charges	$5,682
Annual Benefits		$15,874
Benefit-to-Cost Ratio (BCR)		2.8
Net Benefits		**$10,191**

[6] The $2,000 in operation and maintenance reflects only the operation and maintenance on dam components associated with the recommendations included this DSA evaluation report.